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Comments "On Minimizing the Consequences of Nuclear War" by Carl Sagan

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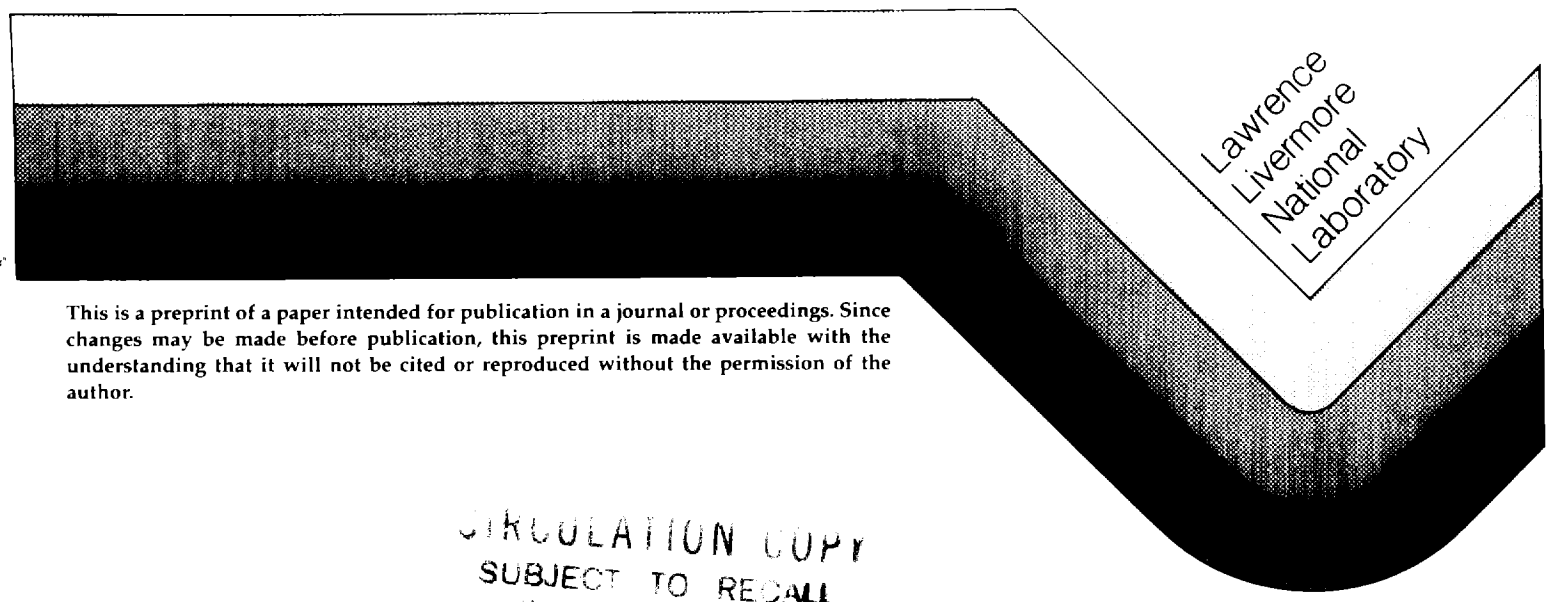

DISCLAIMER

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The Editor
Nature
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Dear Sir:

We wish to respond to some of the comments regarding fallout in "On Minimizing the Consequences of Nuclear War." [1] Our remarks are made in the spirit that the goal of scientists is to be as accurate and unbiased as possible in assessing the potential or alleged impacts of an event such as nuclear war, and that either minimizing or maximizing these consequences is a disservice to the general public and to decision makers who seek guidance. If scientists are not accurate, credibility is lost and messages from the scientific community will eventually be ignored.

Fallout is generally divided into several components: local (or early) fallout (first 24 hours) and global (or delayed) fallout. Global fallout can be further subdivided into an intermediate time scale (1 to 30 days; sometimes called tropospheric) and long-term (beyond 30 days; sometimes called stratospheric) fallout.

Local Fallout

To our knowledge, the serious consequences of local fallout have been accepted by the scientific community for over three decades. Projections of the intensity and extent of local fallout are highly sensitive to a number of variables, which helps explain why different assessments have produced widely different results. Uncertainties in these projections can be divided into three categories, those due to (a) the targeting scenario, (b) the fallout calculational model, and (c) the selected meteorological conditions.

(a) The targeting scenario contains variables such as numbers of weapons, the yield mix, fission fraction, height of burst, and precise target locations. The height of burst (HOB) is of particular significance because air bursts do not produce significant local fallout, except for the possible rainout of debris from tactical yield weapons. Only when the fireball interacts with the ground (a ground level or near ground burst) does significant local fallout ensue. A reasonable assumption often made is that hardened military targets are targeted with ground bursts. For "the softer" industrial and other military targets, maximum damage is accomplished by air bursts where the HOB can be optimized. The primary fires hypothesised in urban areas in "nuclear winter" studies are assumed to be initiated by airbursts, because ground bursts have shorter range for initiating fires. Hence, maximizing smoke production implies minimizing local fallout. (b) Uncertainties in dose calculations in the best fallout models originate from several sources. These uncertainties are due to limited experimental calibration data, whether the modeled radioactivity is rigorously conserved, and whether time of arrival is properly accounted for. (c) Assumptions about selected meteorology, wind velocities, shears, precipitation patterns,

etc. affect the results. Hence, local fallout assessments can vary greatly depending on these many assumptions.

For assessing the human impact of local fallout, additional factors must be considered. By far the most sensitive of these is the protection factor afforded by homes, buildings, basements, shelters, etc. These structures can dramatically mitigate the unprotected dose assessments normally cited and used in public presentations. An additional important consideration is the assumption of what the lethal acute external whole body dose levels are (values of the LD_{50} from 250 to 600 rems external have been reported). Finally, for radiation exposure that is protracted in time, biological repair of the resulting damage is important in mitigating the effects[2]. This is especially important with regard to global fallout, where the dose is received slowly over many years. Dose effectiveness factors from 0.1 to 0.5 for chronic exposures have been suggested[2]. This means that a large chronic dose will have an effect equivalent to a much smaller acute dose. Any presentation that implies that our planet would be a radioactive desert of certain demise is not including these important factors in a balanced sense; hence, inaccurate and biased estimates can be created.

Calculations of total fatalities produced by large scale attacks on the continental U.S. undertaken by our group have produced estimates of fallout fatalities (after subtracting those already killed by blast and thermal effects) that range over almost 2 orders of magnitude. This large variation in fallout fatalities is well understood in terms of variations in the parameters discussed above. As part of our contribution to the recent International Council of Scientific Unions SCOPE-ENUWAR study on the environmental effects of nuclear war[3], we undertook calculations of local fallout using the computer model KDFOC2[4], using single burst fallout patterns and a semi-empirical approach for multiple explosions. Calculations were done for a 6000 megaton multi-phase counterforce-countervalue nuclear exchange. Results indicated that about 7% of the land areas of the U.S.A., U.S.S.R., and Europe would receive a minimum of 450 rads within 48 hours. This assumed no shielding and would apply to a population unprotected by structures. The SCOPE-ENUWAR study[5] was primarily concerned with direct effects on unprotected plants and animals and excluded direct effects on humans (it did of course consider the very important indirect effects on humans). In considering direct effects on humans, protection factors and population distribution should be added into the picture, with the result that land area envelopes are reduced below 7% by factors of several (land area envelopes scale very roughly as the inverse of the protection factor). As an example, Daugherty, Levi and Von Hippel, in their recent study[5] used protection factors of 3 for rural areas and 10 for urban areas. The figure of 30% of all northern-midlatitude land areas receiving an acute mean lethal dose to humans obtained by TTAPS and quoted in[1] by Sagan is clearly much higher than our SCOPE result, and we believe seriously inaccurate.

Global Fallout

There is a hint of "On the Beach" in Sagan's discussions of global fallout; the specter of a cloud of lethal levels of radioactivity spreading around the globe. Our group first reported in 1983[6] that long- term total doses of 100 rem or larger in global fallout hot spots are possible. Sagan refers to this, and then interjects the possible effects of a 100 rem acute dose on the immune system (a speculative new result). This may mislead the reader as there is an immense difference in the effects of an acute and a long-term (lifetime or 50 year) dose.

The calculations at Livermore on global fallout reported in 1983[6] were supplemented by additional work in 1984[7]. The original results utilizing the GLODEP2 code[8] assumed an atmosphere unperturbed by smoke. These were supplemented by new work utilizing GRANTOUR,[9] a fully interactive microphysical, 3 dimensional global circulation model code developed at LLNL. Doses were calculated with and without smoke in the atmosphere to assess the impact of a perturbed climate on global fallout.

Our GLODEP2 calculations for strategic nuclear exchanges of 5 to 6 thousand megatons predict that the 50 year unsheltered unweathered average external total body gamma dose levels in the Northern Hemisphere would be about 15 rads, and about 0.5 rad in the Southern Hemisphere. The maximum of 30 to 40 rads appears in the 30° to 50° north latitude band. Values predicted for the global population (chronic) dose are typically about 6×10^{10} person-rads. The dose in hot spots, obtained using an area grid of 10° latitude by 10° longitude, are a factor of 6 to 8 higher than the Northern Hemisphere averages. These results have an estimated confidence level of about a factor of 2. Fifty to seventy-five percent of the global fallout dose is due to the tropospheric injections of radionuclides that are deposited in the first month.

The additional calculations, utilizing GRANTOUR involving a perturbed "nuclear winter" atmosphere indicate that the above dose assessments would be about 15% lower in the Northern Hemisphere and marginally higher (approximately 1 rad) in the Southern Hemisphere compared to the unperturbed atmosphere predictions. These results are consistent with the projection that smoke injections can increase vertical stability, inhibit precipitation, and increase interhemispheric transport. We note that the GRANTOUR calculations utilizing a fully interactive microphysical approach with a three dimensional global circulation model produced results that were in good general agreement with the GLODEP2 results that depended on empirical observations from past atmospheric tests.

These calculations have been presented at a number of scientific meetings, including the ICSU-SCOPE workshop on radiation held in Paris in October of 1984. There, an international array of radiation experts reviewed this work in detail, and it then became the basis of the chapter on radioactivity in the SCOPE-ENUWAR report[3] and underwent additional external review by dozens of international experts. The effects of these levels of global fallout were summarized in the Report of the Paris Commission on Radiological Dose Assessments and Biological Effects[10]. It concluded "The long-term increase in genetic and carcinogenic effects on humans from global fallout is of the order of 1% of the natural incidence and should be considered a second order effect." No mention is made of pro-dromal effects on humans because at these lifetime dose levels and considering biological repair, pro-dromal effects would not be observed. This does not sound anything like the "On The Beach" scenario or the impression transmitted to the audience at the Washington Sheraton Hotel briefing held by Sagan and others on Halloween, October 1983.

It is true that our original calculations have not been published in a refereed journal, nevertheless they have undergone extensive review as mentioned earlier, far in excess of the normal reviews of a refereed journal. Sagan should however heed the Biblical injunction "let he who has not sinned cast the first stone." Reference 2 in his paper (EOS 63, 1018 (1982) is a 250 word unreviewed abstract of a paper that was to be given at the San Francisco meeting of the American Geophysical Union but was cancelled before presentation. This unpublished/withdrawn reference authored by the "TTAPS team" was cited in Sagan's recent Nature article[1] 10 times!

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Sincerely yours,

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